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The Effects of Pressure on Electron Transport and Local Structure of Manganites: Low to High Pressure Regime

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Beamline(s): X17B

Introduction: The transport properties of manganite system are influenced by the subtle coupling of the spin, charge and lattice degrees of freedom. This coupling has been shown in a large body of pressure dependent transport work as a linear increase of the metal-insulator transition temperature T_{MI} with pressure. However, most of this work was limited to pressures below ~2 GPa. Based on studies on the effects at low pressures, it was generally accepted that pressure is equivalent to the chemical doping and pressure high enough can induce metallic state at room temperature. This has been indirectly proved not true [1, 2].

Methods and Materials: We have studied the system $La_{0.60}Y_{0.07}Ca_{0.33}MnO_3$ which has a transition temperature that enables the observation of shifts in T_{MI} over a broad range of pressures. The experiments included high pressure resistivity and high pressure X-ray diffraction measurements.

Results: In experiments covering the pressure range 1 atm to ~7 GPa, we find that the plot of T_{MI} vs. pressure reaches maximum (while the resistivity reaches minimum) at ~3.8 GPa and then drops (increases) below (above) the 1 atm value above 6 GPa (Fig.1). From structural measurements we find that, depending on the absolute pressure, pressure changes first suppress then induce structural distortion of the MnO_6 octahedra (Fig. 2). The high temperature resistivity is well modeled by a variable range hopping model. The pressure dependence of the localization length is extracted and found to follow the behavior of T_{MI} (Fig. 3).

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References:

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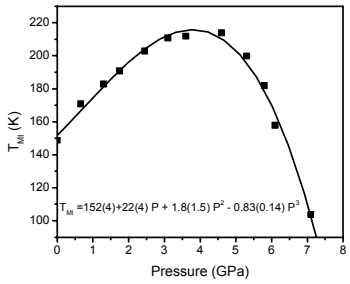

Fig. 1. Pressure dependence of T_{MI}. The solid line is a 3rd order polynomial fit with the coefficient errors in brackets.

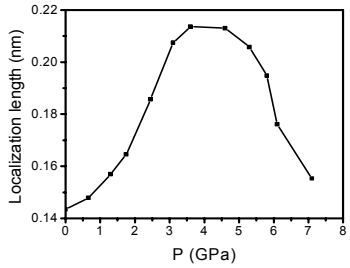

Fig. 3. Localization length evaluated with 3D VRH model. The solid line is a guide to eye.

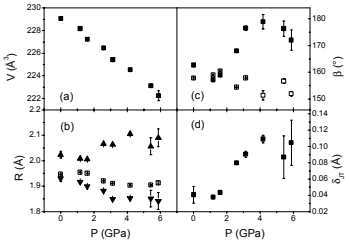

Fig. 2. Pressure dependence of structure parameters for room temperature XRD measurements. (a) unit cell volume; (b) Mn-O bond lengths of the in-plane bonds (up & down solid triangles) and "c-axis" bond (empty squares); (c) The "ab-plane" and "c-axis" bond angles (empty & solid squares); (d)The coherent Jahn-Teller parameter, $\delta_{JT} = \sqrt{\frac{1}{N}\sum(R_{Mn-O} - < R_{Mn-O} >)^2}$.